# PATENT ABSTRACTS OF JAPAN

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(21)Application number : 06-144549   (71)Applicant : TOSHIBA CORP

(22)Date of filing :      27.06.1994  (72)Inventor :  HARA SHIGEHIRO
                                                    UMAGOE TOSHIYUKI
                                                    KOYAMA KIYOMI
                                                    IKENAGA OSAMU

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## (54) METHOD AND APPARATUS FOR CHARGED PARTICLE LITHOGRAPHY

(57)Abstract:

PURPOSE: To exhibit the effect of a CP lithography method sufficiently and realize the lithography whose throughput is significantly high by a method wherein the stage speeds of the respective combinations of candidate cells are calculated from the lithography time by a variable forming beam only and the reduced lithography times which are obtained when the respective candidate cells are characterized and the lithography time is introduced from the respective stage speeds.

CONSTITUTION: Lithpgraphy time required to plot the sample areas by using basic pattern apertures only and respective reduced time when respective candidate cells are characterized and plotted are obtained for all the sample areas. Then the sum of the reduced time corresponding to all the combinations formed by the respective candidate cells in aperture masks 36 are deducted from the lithography time to calculate the lithography time in respective sample areas. The frame lithography time is obtained from the lithography time of the sample area which shows the longest lithography time in that frame. The combination of the candidate cells which offers the shortest lithography time in the whole lithography region is formed on the aperture mask 36.
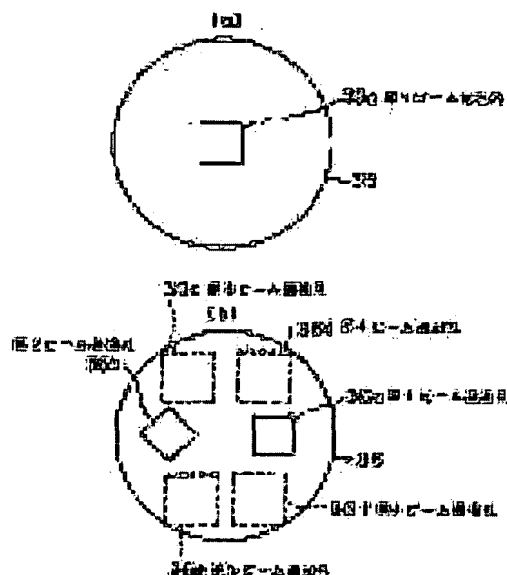
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CLAIMS

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[Claim(s)]

[Claim 1] Carrying out continuation movement of the stage in which the sample was
laid using the aperture mask with which the aperture for elementary figures for
forming the shaped beam corresponding to an elementary figure and the aperture for
characters which is repeatedly equivalent to a pattern were formed In the electric
charge beam drawing method which draws the drawing field (frame) divided into
predetermined width of face one by one It considers as the candidate cell which
should extract the pattern repeatedly used out of the data of the request which
should draw, respectively, and should be made a character cell. The aforementioned
frame is virtually divided in the stage continuation move direction to a small field
(sample area). After calculating each shortening time deltaAc at the time of
character-izing this cell and drawing to the drawing time A required drawing this
sample area only using the aperture for elementary figures, and each candidate cell
about all sample area, By choosing the predetermined number of the aperture for
characters formed in the aforementioned aperture mask from each candidate cell,
creating all combination, and lengthening the sum of corresponding shortening time
deltaAc from the drawing time A to all combination Compute the drawing time in each
sample area, and the drawing time T of the sample area where the drawing time in
each aforementioned frame is the longest is found. The drawing time of each frame is
found by xT. (Width of face of the length / sample area of a frame) The electric charge
beam drawing method characterized by computing the drawing time of all the drawing
fields given by the sum of such frame drawing time, searching for the combination of a
candidate cell with the shortest drawing time of all drawing fields, and forming the
aperture pattern on the aforementioned aperture mask in this combination.

[Claim 2] Electric charge beam drawing equipment which draws a request pattern

combining the character beam formed in the same configuration as the repeat unit which is characterized by providing the following, and which appears repeatedly in the pattern which should draw, and the basic form-like beam fabricated in the shape of [, such as a rectangle and a rectangular equilateral triangle, ] a basic form. The drawing data origination means for creating drawing pattern data from the design pattern data of LSI is the hierarchical graphic-data-processing section which performs graphic data processing predetermined in the state where the hierarchical reference structure which design pattern data have was maintained. The layered structure recombination processing section which reconfigurates design pattern data-hierarchy structure beforehand in order to make the aforementioned hierarchical graphic data processing possible, The character determination processing section which divides the pattern data after the aforementioned hierarchical graphic data processing into the pattern group which draws by the character beam, and the pattern group which draws with the combination of a basic form-like beam, The character control-code substitution processing section which replaces the pattern group which draws by the aforementioned character beam by the control code which shows the classification of the shape of beam, The drawing data output section classified by drawing field assigned to the unit field which can draw the control code which shows the graphic data of a pattern and the classification of the aforementioned character beam which draw by the aforementioned basic form-like beam.

[Claim 3] The aforementioned character determination processing section analyzes the result of the aforementioned graphic data processing by making into a unit the pattern group (cell) which became a batch on the occasion of the aforementioned hierarchical graphic data processing. The cell information analysis processing which computes a cell identification number, the number of cell references, a cell size, a basic form-like beam conversion shots per hour, and a character beam conversion shots per hour, The first character-ized candidate cell selection processing which chooses the high cell of a character-ized effect as a character-ized candidate cell, Character-ized candidate cell reconstruction processing in which the content of a pattern definition of the cell chosen as a candidate cell is processed, The second character-ized candidate cell selection processing which chooses a predetermined number from the reconfigurated candidate cell, It consists of character-ized effect evaluation processings in which a character-ized effect is evaluated about the combination of the selected cell. Electric charge beam drawing equipment according to claim 2 characterized by repeating character-ized candidate cell reconstruction processing, the second character-ized candidate cell selection processing, and

character-ized effect evaluation processing, and determining the combination of a suitable character-ized cell.

[Claim 4] The pattern with which the circumscription rectangle of a pattern existence region is defined for the aforementioned character-ized candidate cell reconstruction processing in the cell below predetermined size, Or partial hierarchy expansion down stream processing which develops the pattern defined in the specified cell in the cell which is referring to the cell concerned, Partial extraction down stream processing which extracts the figure group in a cell partially and is newly defined as a cell, Pattern recognition down stream processing it will be considered that is the same cell if its pattern configuration defined as the interior is the same, although cell identification numbers differ, Array reconstruction down stream processing divided with the maximum beam size after developing the cell array concerned within the limits of it in quest of the reference pitch of a cell and the least common multiple of the maximum beam size by which array reference is carried out, electric charge beam drawing equipment according to claim 3 characterized by carrying out shell composition.

[Claim 5] The electric-charge beam drawing equipment according to claim 2 characterized by to compute a difference with the drawing time at the time of drawing by the drawing time and the character beam at the time of drawing by the basic form-like beam as an evaluation norm at the time of evaluating the character-ized effect in the aforementioned character determination processing section, and only for a predetermined number to character-ize the high cell of a character-ized effect.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the electric charge beam drawing method and drawing equipment which carry out package exposure of the repeat pattern section represented by especially the memory device with respect to the electric charge beam drawing technology for drawing the pattern of semiconductor integrated circuits, such as LSI, at high speed and with high precision in samples, such as a mask and a wafer.

[0002]

[Description of the Prior Art] Since an electron beam machine can amend a deviation, and distortion and aberration of a beam electrically, it has the advantage in which

precision is high, and is widely used as an LSI development tool and a mask manufacture tool now while being able to draw the very detailed pattern equivalent to a beam diameter.

[0003] Although the equipment which draws by the Gaussian beam or the variable shaped beam in the so-called way of a picture drawn without lifting the brush from the paper was in use conventionally as this electron beam machine, the more the pattern was detailed and became complicated, the shots per hour increased and, the more there was a fault that a throughput fell. then, transparency of a large number corresponding to each repeat Batang configuration paying attention to many of basic circuits of recently and a semiconductor integrated circuit being the repeats of the same Batang —— the electron beam machine of the package exposure (it omits character projection and Following CP) method equipped with the mask (it is hereafter called a aperture mask) in which the hole was formed is developed

[0004] By the way, including all of the figure which appears repeatedly, or a figure group in a aperture mask in the electron beam machine of continuous path control needs to draw by eye an impossible hatchet, and the remainder needs to draw in the combination of an elementary figure. Therefore, drawing time changes to a aperture mask by a figure group [ which figure or ] is incorporated. That is, it is very important to choose a thing suitable as a pattern for including in a aperture mask when raising the throughput of drawing.

[0005] As 1st conventional example, high effectiveness is set as the order whose total of an exposure shot decreases to this candidate block data while extracting the pattern data repeatedly used in JP,5-13313,A out of pattern data, dividing these pattern data for every predetermined size and considering as candidate block data, and it constitutes so that it may have a block pattern extraction means to extract the block pattern of a predetermined number alternatively out of this candidate block data.

[0006] As 2nd conventional example, the feature figure or the feature figure group which requires many shots per hours by the case where it is assumed out of the feature figure which appears repeatedly in Batang which should draw as a pattern built into a aperture mask in JP,4-320021,A, or the feature figure group that the shot was carried out in the combination of the shaped beam corresponding to the aforementioned aperture for elementary figures is chosen preferentially, it forms, and lessening the total of an exposure shot is indicated.

[0007] By the way, there are some which are called stage continuation move drawing method which draws while moving continuously in the sample base (stage) on which the wafer which should be drawn was put in an electron beam machine. As shown in

drawing 16 , this method is a method which draws per frame and goes, dividing by the width of face (frame) which can deflect [ of an electron beam ] all drawing fields, and moving continuously on a stage. In addition, let stage speed be a fixed thing with each frame.

[0008] By such electron-beam-lithography method of stage continuation movement, the drawing time of each frame is given at (frame length / stage speed), and the drawing time of the whole drawing field is given by the sum of the drawing time of this frame, and the sum of the time of overheads, such as time of the clinch in a stage edge. Therefore, by this method, in order to decide drawing time by stage speed and to raise a drawing throughput, it needs to optimize stage speed as much as possible, and needs to accelerate.

[0009] As 3rd conventional example, the electric charge beam drawing method that it can ask for the optimal traverse speed of a stage simply is proposed by JP,4-61221,A, without actually moving a stage. The sum B of the maximum drawing time equivalent to the number of the small fields estimated as the value A which found the required drawing time which drawing takes for every sample area, assumed that it moved at a certain fixed speed on the stage, found the maximum drawing time of the small field in this speed, evaluated the small field in a frame by this method sequentially from the edge, and added the required time of each smallness field is compared. And it made into the decision criterion whether to exceed the sum C of the maximum drawing time when such difference A-B is contained in the maximum beam deflection width of face, and the abbreviation maximum stage traverse speed to which A-B does not exceed C is determined.

[0010] Thus, in the electron-beam-lithography method which adopted continuous path control, high effectiveness is set as the order whose total of an exposure shot decreases to the extracted candidate block data, and the method determined as a block which extracts the block pattern of a predetermined number from a candidate block alternatively, and carries out CP exposure is taken.

[0011] However, in the case of a stage continuation move drawing method, finally, it decides on drawing time in the form of stage speed. The stage speed of each frame is decided by the distribution of the roughness and fineness of not only the total of the shots per hour in a frame but a shots per hour, the arrangement format of a cell data, etc. For this reason, by the electric charge beam drawing method of stage continuation movement, there was a trouble that stage speed did not change, therefore the throughput of drawing did not improve with the arrangement format of the distribution of the roughness and fineness of a shots per hour or a cell data etc.

even if it adopts it as the order whose total of an exposure shot decreases as a CP cell.

[0012] Moreover, a total combination which selects the candidate cell of a predetermined number and can do it from CP candidate cell is created, stage speed and drawing time are computed about each of combination, and the method of choosing the combination to which drawing time becomes the shortest is expected so that it may be easily guessed from the 3rd conventional example. However, by this method, in order to find each drawing time with the application of the method of the conventional example of a repeat 3rd about each of total combination, the problem that the time of the processing becomes huge is expected.

[0013] On the other hand, when drawing a circuit pattern using the electron beam exposure system which adopted continuous path control, it is necessary to change the design pattern data created using circuit pattern-design tools, such as CAD (Computer Aided Design), into the electron-beam-lithography data format which fulfilled conditions, such as specification of the data format which can be inputted into an electron beam exposure system, i.e., a drawing method, and drawing equipment. Generally such "transform processing from a design data to drawing data" is called "electron-beam-lithography data conversion." It is as follows when the content of processing of electron-beam-lithography data conversion required for conventional VSB-system drawing equipment is summarized.

(1) Boolean operations of figure between layers (AND, OR, NOT, etc.)

(2) Pattern duplication removal (it is the purpose about prevention of multiplex exposure)

(3) Resizing (thicker/narrowing)

(4) Scale-factor amendment (expansion/reduction)

(5) Spin compensation (rotation/mirror image)

(6) Division of a drawing field unit (it divides by boundary lines, such as a subfield field / frame field)

(7) Elementary figure division (they are division/approximation to the elementary figure which can be inputted into drawing equipment)

(8) Data-format conversion (it changes into a transcription peculiar to drawing equipment, and is an output)

When designing a circuit pattern, a designer defines the figure group first called cell, this is called and arranged within another cell, and the whole pattern is constituted by combining many cells. By performing the above-mentioned graphics processing, with the hierarchical cell reference structure maintained which such a design data has,

shortening of the processing time of drawing TETA conversion and compression of the drawing amount of data are achieved. Such processing technique is called hierarchical graphic data processing.

[0014] The regular pattern of the drawing equipment which adopted continuous path control is continuous path control, and an irregular pattern draws by the VSB system. Therefore, in addition to the above-mentioned function, in the drawing data-conversion processing corresponding to continuous path control, data processing which separates the pattern which carries out VSB drawing by the basic form-like beam, and the pattern which carries out CP drawing by the character beam is needed.

[0015] This separation processing needs to search for regularity from the figure of a large number which constitute a circuit pattern, and needs to extract the unit-hydrograph form group of the repeat as a character configuration. Two points, extract [ not generating the error on drawing data, such as duplication and a gap, between a VSB drawing pattern and CP drawing pattern in that case and ] efficiently a set of the character figure which makes a drawing throughput the optimal, are important. It is necessary to ask for a set of the character figure from which a drawing throughput serves as best under the limit of the number of character kinds, and the maximum beam size based on equipment specification, and the processing is very complicated in especially the latter. For this reason, data-processing time became long and there was a problem of also reducing the throughput of the whole drawing system.

[0016]
[Problem(s) to be Solved by the Invention] Thus, conventionally, by the electric charge beam drawing method of stage continuation movement which adopted continuous path control, since it finally decided on drawing time in the form of stage speed, even if it adopted it as the order whose total of an exposure shot decreases as a CP cell, stage speed changed neither with the distribution of the roughness and fineness of a shots per hour, nor the arrangement formats of a cell data, therefore there was a problem that the throughput of drawing did not improve. Furthermore, by the method guessed from the 3rd conventional example, in order to find each drawing time with the application of the method of the conventional example of a repeat 3rd about each of all combination, the problem that the time of the processing becomes huge is expected.

[0017] Moreover, in the electric charge beam drawing equipment which adopted continuous path control, in order to create drawing data from a design data, graphic

data processing which separates the pattern which carries out VSB drawing by the basic form-like beam, and the pattern which carries out CP drawing by the character beam was needed, the data-processing time for this separation processing became long, and there was a problem of also reducing the throughput of the whole drawing system.

[0018] it is in offering the electric charge beam drawing method that this invention was able to be made in consideration of the above-mentioned situation, the place made into the purpose can fully demonstrate the effect of CP drawing method, very . high drawing of a throughput can be performed, and the decision which is CP cell which should moreover be formed in a aperture mask can be made easily

[0019] Moreover, it is for offering the electric charge beam drawing equipment which can also maintain adjustment with the pattern which other purposes of this invention can extract easily the figure group which carries out package drawing by the character beam from design pattern data, and carries out VSB drawing, can create drawing data, shortens the time which drawing data origination takes, and can aim at improvement in a drawing throughput.

[0020]

[Means for Solving the Problem] The main point of this invention once calculates drawing time deltaAc shortened when the drawing time A at the time of using only the variable shaped beam of each sample area and each CP candidate cell c are character-ized about all sample area, and is to compute the drawing time drawn from A and delta Ac the stage speed of each combination of CP candidate cell, and from now on.

[0021] Namely, the aperture mask with which the aperture for elementary figures for forming the shaped beam corresponding to an elementary figure and the aperture for characters which is repeatedly equivalent to a pattern were formed is used for this invention (claim 1). In the electric charge beam drawing method which draws the drawing field (frame) divided into predetermined width of face one by one while carrying out continuation movement of the stage in which the sample was laid It considers as the candidate cell which should extract the pattern repeatedly used out of the data of the request which should draw, respectively, and should be made a character cell. A frame is virtually divided in the stage continuation move direction to a small field (sample area). After calculating each shortening time deltaAc at the time of character-izing this cell and drawing to the drawing time A required drawing this sample area only using the aperture for elementary figures, and each candidate cell about all sample area, By choosing the predetermined number formed in a aperture

-8-

mask from each candidate cell, creating all combination, and lengthening the sum of corresponding shortening time deltaAc from the drawing time A to all combination Compute the drawing time in each sample area, and the drawing time T of the sample area where the drawing time in each frame is the longest is found. The drawing time of each frame is found by xT. (Width of face of the length / sample area of a frame) The drawing time of all the drawing fields given by the sum of such frame drawing time is computed, the combination of a candidate cell with the shortest drawing time of all drawing fields is searched for, and it is characterized by forming the aperture pattern on a aperture mask in this combination.

[0022] Here, the following are raised as a desirable embodiment of this invention.

(1) Set up the traverse speed of a stage the optimal for every frame. Drawing time of the sample area which starts most in a frame as for drawing time is more specifically set to T, and stage traverse speed is set up by the width of face/T of sample area.

(2) Search for the combination of a candidate cell, seting as constant the number of the character cells formed in a aperture mask.

(3) Make adjustable the number of the character cells formed in a aperture mask with the size of a candidate cell, and search for the combination of a candidate cell. More specifically, as the sum of the area of each candidate cell goes into predetermined within the limits, the combination of a candidate cell is searched for.

[0023] Moreover, another main point of this invention replaces the figure group which determines and character-izes the configuration of a character beam by the continuous-path-control code by making the figure group (cell) used as the batch of hierarchical graphic data processing into a unit in advance of the processing which separates the pattern by which VSB drawing is carried out, and the pattern by which CP drawing is carried out, and is for constituting drawing data-conversion processing so that a VSB drawing pattern and a continuous-path-control code may be outputted as drawing data per drawing field.

[0024] Namely, the character beam formed in the configuration as the repeat unit which appears repeatedly in the pattern which should draw where this invention (claim 2) is the same, In the electric charge beam drawing equipment which draws a request pattern combining the basic form-like beam fabricated in the shape of [, such as a rectangle and a rectangular equilateral triangle, ] a basic form The hierarchical graphic-data-processing section which performs graphic data processing predetermined in the state where the hierarchical reference structure where design pattern data had a drawing data origination means for creating drawing pattern data from the design pattern data of LSI was maintained, The layered structure

recombination processing section which reconfigurates design pattern data-hierarchy structure beforehand in order to make hierarchical graphic data processing possible, The character determination processing section which divides the pattern data after hierarchical graphic data processing into the pattern group which draws by the character beam, and the pattern group which draws with the combination of a basic form-like beam, The character control-code substitution processing section which replaces the pattern group which draws by the character beam by the control code which shows the classification of the shape of beam, It is made to carry out shell composition with the drawing data output section classified by drawing field assigned to the unit field which can draw the control code which shows the graphic data of a pattern and the classification of a character beam which draw by the basic form-like beam.

[0025] Here, the following are raised as a desirable embodiment of this invention.

(1) Analyze the processing result of hierarchical graphic data processing for a cell as a unit in the character determination processing section. The cell information analysis processing which creates the chart which consists of a cell identification number, the number of cell references, a cell size, a basic form-like beam conversion shots per hour, and a character beam conversion shots per hour, The first character-ized candidate cell selection processing which chooses the high cell of a character-ized effect as a character candidate cell, Character-ized candidate cell reconstruction processing in which the content of a pattern definition of the cell chosen as a candidate cell is processed, The second character-ized candidate cell selection processing which chooses only a predetermined number from the reconfigurated candidate cell, Processing called character-ized effect evaluation processing in which a character-ized effect is evaluated about the combination of the selected cell is performed. Repeat character-ized candidate cell reconstruction processing, the second character-ized candidate cell selection processing, and character-ized effect evaluation processing, and determine the combination of a suitable character-ized cell.

(2) In character-ized candidate cell reconstruction processing The partial hierarchy expansion processing which develops the pattern with which the circumscription rectangle of a pattern existence region is defined in the cell below predetermined size, or the pattern defined in the specified cell in the cell which is referring to the cell concerned, The pattern recognition processing whose pattern configuration defined as the interior considers that the same cell is the same cell although cell names differ, The array reconstruction processing divided with the maximum beam size after developing the cell array concerned within the limits of it in quest of the reference

pitch of a cell and the least common multiple of the maximum beam size by which array reference is carried out, Process the pattern in a cell combining the partial extraction processing which extracts partially and is newly used as a cell.

(3) Compute a difference with the drawing time at the time of drawing by the drawing time and the character beam at the time of drawing by the basic form-like beam as an evaluation norm at the time of the character determination processing section estimating a character-ized effect, and only a predetermined number should character-ize the high cell of a character-ized effect.

(4) Perform figure division on figures duplication removal, the boolean operation of figure between layers, and a unit deviation field boundary, resizing processing, etc. as graphics processing in the character determination processing section.

[0026]

[Function] Once it calculates shortening time deltaAc at the time of character-izing the drawing time A required drawing sample area only using the aperture for elementary figures according to the method of this invention (claim 1), and a candidate cell, and drawing, the drawing time of all the combination of CP candidate cell can be found simply after this. Consequently, drawing time can choose easily the combination of the candidate cell which is the shortest. That is, extraction of CP candidate cell for fully demonstrating the effect of CP drawing method and performing very high drawing of a throughput is obtained by short-time efficient processing.

[0027] Moreover, since according to this invention (claims 2-4) hierarchical graphic data processing is performed before separating a VSB drawing pattern and CP drawing pattern, the drawing data of the request which does not have error parts, such as duplication or a gap, among both can be created in a short time. For this reason, the data-processing time for separation processing becomes short, and it becomes possible to raise the throughput of the whole drawing system of it.

[0028] Moreover, the same cell as the batch of hierarchical graphics processing is first extracted as a first character candidate in a unit, and since 2 stage selection method by which a character-ized effect is evaluated again is adopted after performing candidate cell reconstruction processing of division, fusion, etc., the combination of a suitable character figure can be determined in a short time. Furthermore, since the time difference of VSB drawing and CP drawing estimates a character-ized effect, the suitable character set based more on reality can be determined.

[0029] In view of the inclination of detailed-izing of LSI in recent years, and high integration, the problem and bird clapper with serious processability ability of electric

charge beam drawing equipment are expected. On the other hand, drawing equipment equipped with the creation means of drawing data like this invention not only can shorten the processing time which drawing data conversion corresponding to CP drawing method takes, but it can also raise drawing processability ability simultaneously and the usefulness is size.

[0030]

[Example] Hereafter, the example of this invention is explained with reference to a drawing.

(Example 1) Drawing 1 is the outline block diagram showing the electron beam machine used for the 1st example of this invention. Ten in drawing is a sample room and the table (stage) 12 which laid the samples 11, such as a semiconductor wafer or a glass mask, is held in this sample room 10. A table 12 is driven by the table drive circuit 13 in the direction of X (space longitudinal direction), and the direction (the direction of the space table reverse side) of Y. And the position of a table 12 is measured by the position circuit 14 which used the laser length measurement meter etc.

[0031] The electron beam optical system 20 is arranged above the sample room 10. This optical system 20 consists of an electron gun 21, the various lenses 22–26, the deflecting system 31 for blankings, deflecting system 32 for beam size adjustable, subdeflecting system 34 for a beam scan, aperture masks 35 and 36 for beam fabrication, etc.

[0032] And while it positions to a predetermined unit drawing field (subfield) with the main deflecting system 33 and the subdeflecting system 34 performs figure drawing positioning within a subfield, the shape of beam and a beam size are controlled by the deflecting system 32 for shape-of-beam control, and the aperture masks 35 and 36 for beam fabrication, and drawing processing is carried out per drawing stripe which collected the frame fields which divided the LSI chip in the shape of a strip of paper according to beam deflection width of face, carrying out continuation movement of the table 12 in X or the direction of Y. Furthermore, the table 12 was moved to the starting position of the following drawing stripe, the above-mentioned processing was repeated, and drawing processing of each drawing stripe has been carried out one by one.

[0033] On the other hand, the storages 41 including a magnetic disk are connected to the control computer 40, and the drawing data concerning the LSI chip made applicable to drawing at this magnetic disk 41 are stored. The drawing data read from the magnetic disk 41 are temporarily stored in the pattern memory 42 as drawing data

for every aforementioned drawing stripe. The drawing stripe data which consist of drawing data, i.e., the drawing position, elementary figure data, etc. for every drawing stripe stored in the pattern memory 42 are decoded by the pattern data decoder 43 and the drawing data decoder 44 which are the data decode section, and are sent out to a blanking circuit 45, the beam fabrication driver 46, the main deviation driver 47, and the subdeviation driver 48.

[0034] That is, in the pattern decoder 43, the above-mentioned drawing stripe data are inputted, figure division of the elementary figure data defined as drawing stripe data is carried out in a figure group at drawing unit-hydrograph type groups including CP cell figure or the rectangle which can be formed with combination, and triangle of the aforementioned aperture masks 35 and 36 for beam fabrication, and it is sent to the beam fabrication driver 46 created based on this drawing figure information. And a predetermined deviation signal is impressed to the deflecting system 32 for shape-of-beam control of an electron optics system 20 from the beam fabrication driver 46, and the shape of beam and the beam size of an electron beam are being controlled.

[0035] Next, the generation method of the beam in the equipment mentioned above is explained in full detail. drawing 2 (a) -- beam passage of the 1st aperture mask 35 for beam fabrication -- what shows arrangement of a hole -- it is -- one beam passage -- a hole -- 35a is formed drawing 2 (b) -- beam passage of the 2nd aperture mask 36 for beam fabrication -- arrangement of a hole -- being shown -- **** -- the 1st - the 6th passage -- Holes 36a-36f are formed

[0036] the beam passage to which drawing 3 was formed in the aperture image (the 1st shaping-aperture image) of the 1st aperture mask 35 for beam fabrication, and the 2nd aperture mask 36 for beam fabrication -- signs that the electron optics-superposition of a hole generates the desired shape of beam and a desired beam size are shown drawing 3 (a) -- the 1st beam passage of the 1st shaping-aperture image and the 2nd fabrication aperture mask 36 -- a hole -- it is in the state which is generating the rectangle beam with combination with 36a drawing 3 (b) -- the 2nd beam passage of the 1st shaping-aperture image and the 2nd fabrication aperture mask 36 -- a hole -- it is in the state which is generating the triangle beam with combination with 36b A rectangle beam and a triangle beam serve as a unit drawing figure for carrying out drawing processing of the pattern section which cannot carry out a package imprint in the aperture projection image of the 2nd fabrication aperture mask 36.

[0037] the beam passage for CP cell projection by which drawing 3 (c) was formed in

the 1st shaping-aperture image and the 2nd fabrication aperture mask 36 -- it is in the state which is generating the beam image equivalent to a part of design data with Holes [ 36c-36f ] one of combination Using the beam generation method explained in full detail above, as shown in the example of drawing 4 , the LSI chip is exposed using the beam for elementary figures which consists of the beam, triangle, or rectangle for a package imprint.

[0038] Next, in case it draws using this example equipment, it explains how CP aperture figure formed on a aperture mask is chosen. Drawing 5 is the flow chart which showed the flow of the processing at the time of determining CP cell according to this example. According to this flow chart, the content of processing is explained in full detail.

[0039] First, a pattern is repeatedly extracted from the design of an LSI pattern (S1). Subsequently, the extracted repeat pattern is divided or united, and pattern size is optimized so that it may become a size about [ for CP ] aperture (S2). Hereafter, it is made the thing which it did in this way and was optimized and which call a pattern CP candidate cell repeatedly.

[0040] Subsequently, it asks for the shots per hour at the time of exposing the number of times of reference in the whole LSI of CP candidate cell, and each CP candidate cell only using a variable shaped beam (S3). For example, when the design data of LSI Batang which draws was analyzed, it turns out that there are four kinds of repeat patterns of A-D like drawing 6 . Moreover, four kinds of repeat patterns were optimized in the size about CP aperture size, and eight CP candidate cells A and B1 like drawing 7 , B-2, and C1, C2, C3, C4 and D were created. However, the method of dividing simply is taken in this example. Moreover, the result which asked for the number of times of reference and the shots per hour of eight CP candidate cells is the following (table 1).

[0041]
[Table 1]

| 種　類 | 換算ショット数 | 参照回数 | 仮想ショット数 |
|---|---|---|---|
| A | 70 | $8 \times 10^7$ | $5.6 \times 10^9$ |
| B 1 | 100 | $4 \times 10^7$ | $4.0 \times 10^9$ |
| B 2 | 98 | $4 \times 10^4$ | $3.9 \times 10^9$ |
| C 1 | 80 | $1 \times 10^4$ | $8.0 \times 10^5$ |
| C 2 | 83 | $1 \times 10^4$ | $8.3 \times 10^5$ |
| C 3 | 110 | $1 \times 10^4$ | $1.1 \times 10^6$ |
| C 4 | 105 | $1 \times 10^4$ | $1.1 \times 10^6$ |
| D | 82 | $2 \times 10^4$ | $1.6 \times 10^6$ |
| 周辺部 | $7 \times 10^7$ | $- - -$ | $7.0 \times 10^7$ |

[0042] Subsequently, the candidate cell of the predetermined number which can be formed in a aperture mask is chosen from CP candidate cell, and a possible combination is created (S4). For example, as shown in drawing 2 , when the aperture for CP is possible on a four-piece aperture mask, 8C4 =70 kind combination is created in the example of drawing 7 .

[0043] Subsequently, the drawing time at the time of exposing CP candidate cell which belongs to each combination about all the combination of CP candidate cell as a character cell according to the flow chart of drawing 8 is computed (S5). Hereafter, this calculation method is explained in detail.

[0044] First, the whole chip is divided into a frame and sample area, and the required drawing time A at the time of drawing each sample area only by the variable shaped beam is found. Simultaneously, drawing shortening time deltaAc of each SAMPURIRU area for every candidate cell at the time of carrying out CP exposure of the candidate cell c is calculated. Here, a frame is the field which divided the drawing field into the stripe of the predetermined width of face decided by the scan width of deflecting system, and sample area is the field which divided the frame in the stage continuation move direction to the small field virtually.

[0045] the drawing time A at the time of drawing the j-th sample area of the i-th frame hereafter only using a variable shaped beam -- new -- tijVSB ** -- if it will write -- the case of the above-mentioned drawing equipment -- tijVSB =Nsub xts1+(Nshot-Nsub) xts2+Nshotxtd -- It is given by (1). However, the ts1:main

-15-

deviation settling time ts2: Subdeviation settling time td : Irradiation time Nsub : The shots-per-hour subfield of the j-th sample area of the frame of eye the number Nshot:i watch of subfields of the j-th sample area of the i-th frame: It is the field which can be exposed only by switch of a subdeviation.

[0046] moreover -- if shortening drawing time deltaAc in comparison with the case where the candidate cell c is exposed in the j-th sample area of the i-th frame only by the variable shaped beam at the time of carrying out CP exposure is newly written to be deltatijc deltatijc=(Nshot, c (VSB)-Nshot, c (CP)) x (ts2+td) -- It is set to (2). However, Nshot, c (VSB) : it is the total shots per hour at the time of carrying out CP exposure of all the cells C in the total shots-per-hour Nshot at the time of exposing all the cells C only by VSB in the j-th sample area of the i-th frame, and the j-th sample area of a c(CP):i position frame. Similarly, it is tijVSB about all sample area. deltatijc is calculated. Moreover, it shall ask [ tijc / delta] about all CP candidate cells.

[0047] Next, it is Above tijVSB about drawing time required about each of the combination of CP candidate cell mentioned above to draw the whole chip. And how to search for from deltatijc is explained. About the candidate cell in <u>drawing 7</u> , combination (A, B1, C1, D) is taken for an example, and the calculation method is explained. First, the required drawing time in each sample area of each frame is computed by the following formulas noting that A, B1, C1, and D are exposed by continuous path control and the remaining portion of a chip is exposed by the variable shaped beam.

[0048]

tij=tijVSB-deltatijA-deltatijB1-deltatijC1-deltatijD -- (3), i.e., the required drawing time in each sample area, should just lengthen a shortened part of the drawing time by character-izing from time required to draw only using a variable shaped beam, as shown in <u>drawing 9</u> . In addition, required drawing time [ in / each sample area / in <u>drawing 9</u> (a) ] and <u>drawing 9</u> (b) show the corresponding ** type view of a frame.

[0049] Next, the stage speed in each frame is computed based on this value. First, it asks for the longest sample area of required drawing time for every frame, and let the highest speed which can draw this sample area be stage speed. That is, supposing the large sample area of required drawing time is the m-th sample area on the i-th frame, the stage speed vim is vim=l/tim. -- It is set to (4). However, l is the width of face of sample area.

[0050] Therefore, actual drawing time ti of the i-th frame ti =L/vim -- It can be found with (5).

[0051] If this processing is performed about all frames, they will be all the drawing time

$$T a l l = \sum_i t' \qquad \cdots (6)$$

Tall.

It can be come out and found.

[0052] The above processing is performed about all the combination of a candidate cell, the drawing time of the whole chip is found from each combination, and CP candidate cell of the combination from which drawing time became the shortest is chosen as an aperture figure for CP of a aperture mask (S6). namely, — Topt=Min (T1 all, T2 all, —) — CP candidate cell which belongs to the combination which gives Topt as (7) is created as a CP aperture figure of a aperture mask. However, Tk all It is the drawing time of the whole chip at the time of carrying out CP exposure of the combination of k—th CP candidate cell.

[0053] Thus, in the electron beam machine of stage continuation move mode, by forming in the aperture mask the combination of CP candidate cell to which drawing time becomes the shortest, an exposure shots per hour can be lessened and, according to this example, improvement in a drawing throughput can be aimed at.

[0054] And drawing time can choose easily the combination of the candidate cell which is the shortest by once calculating drawing time deltaAc shortened when the drawing time A at the time of using only the variable shaped beam of each sample area in this case and each CP candidate cell c are character—ized about all sample area, and computing the stage speed of each combination of CP candidate cell, and the drawing time drawn from now on from A and delta Ac. That is, in case it asks for the repeat pattern which is effective in shortening drawing time most, a useless procedure can be skipped and efficient selection can be carried out.

(Example 2) Drawing 10 is the block diagram showing the 2nd example of this invention, and shows the composition of a drawing data origination means to create drawing data from a design data especially.

[0055] The drawing equipment of this example consists of a drawing data origination means 50 and a drawing means 60. The drawing data origination means 50 consists of the layered structure recombination processing section 51, the hierarchical graphic—data—processing section 52, the character—ized cell determination processing section 53, the character control—code substitution processing section 54, and the drawing data output section 55 classified by drawing field. The drawing means 60 is the same as that of what is equivalent to the main part of drawing equipment, and was shown in aforementioned drawing 1 .

[0056] The layered structure recombination processing section 51 is pretreatment of

hierarchical graphic data processing following this, it reads a design data, reconfigurates the layered structure, and prevents that error parts, such as figure duplication or a gap, occur near a cell boundary by hierarchical graphic data processing. The hierarchical graphic-data-processing section 52 performs graphic data processing, such as figure duplication removal, boolean operation of figure between layers, resizing, and scale-factor amendment, per cell, with the layered structure of a design data maintained.

[0057] As shown in <u>drawing 11</u> , by making a regular pattern space into CP drawing field, the character-ized cell determination processing sections 53 are the other basic form-like beam drawing field and processing to separate, based on the processing result of hierarchical graphic data processing, evaluate a character-ized effect per cell and determine a set of a character-ized cell. By adopting as a unit of the figure group which character-izes the cell which the designer defined as a unit repeatedly at the time of a circuit pattern design, the time and effort which extracts a unit from a circuit pattern repeatedly is sharply mitigable.

[0058] The character control-code substitution processing section 54 is processing which extracts the graphic data of the cell it was decided that character-ization would be, and is transposed to a character control code. The character control code is taken as the control code which discriminates a character configuration, in case a drawing means generates a character beam.

[0059] According to a drawing position, per drawing field, VSB drawing data and a character control code are distributed (frame field etc.), and, as for the last drawing data output section 55 classified by drawing field, are outputted. The drawing data corresponding to CP drawing method are created by the above processing.

[0060] Next, the detail of character-ized cell determination processing is explained based on the block diagram of the character-ized cell determination processing section 53 shown in <u>drawing 12</u> . The character-ized cell determination processing section 53 consists of cell information analysis section 53a, first candidate cell selection section 53b, candidate cell reconstruction section 53c, 53d of the second candidate cell selection sections, and character-ized effect evaluation section 53e.

[0061] Cell information analysis section 53a reads the graphic data in a cell and cell arrangement data which it is as a result of [ of hierarchical graphic data processing ] processing, and creates a cell information table. This cell information table consists of items, such as a shots per hour at the time of drawing with the cell identification number assigned by each cell, the cell size which is the size of the circumscription rectangle of the figure defined in the cell, the total number of references in the chip of

the cell, and a basic form-like beam, and a shots per hour at the time of character-izing.

[0062] Based on this cell information table, the comparatively high cell of a character-ized effect is chosen as a first character-ized candidate cell by first candidate cell selection section 53b, the number of the cells set as the object of future processings is extracted, and the processing load is mitigated.

[0063] By character-izing a cell in a unit, it becomes sharply easy to extract a unit from a circuit pattern repeatedly. However, the size and the number of kinds are arbitrary because of the figure group as which, as for the cell, it defined at the time of a design. On the other hand, as for the character, size and the number of kinds are restricted from restrictions of equipment specification. Therefore, the first character candidate cell may be unable to be character-ized as it is. Then, while making it a suitable cell size, it is necessary to reconfigurate the content of a definition of a candidate cell so that the maximum practical use of the limited number of character kinds can be carried out. The following processings are performed in candidate cell reconstruction section 53c.

(1) Explain the detail of each content of processing below to the partial extraction (3) pattern-recognition (4) array reconstruction (5) cellular splititting of the partial expansion (2) pattern of a layered structure.

(1) As shown in the partial development 13 of a layered structure (a), array arrangement of the cell B shall be carried out within Cell A, and reference arrangement of the cell F shall be carried out by four kinds of orientation within Cell B (the subscript of F shows orientation). If this reference structure is expressed with a face-side notation, it will become drawing 13 (b). The cell size of Cell F is 1/2 or less [ of the maximum beam size ], and if Cell B is character-ized in a unit, it can carry out package drawing of the field of four cells F. However, although reference arrangement of the cell F is carried out within Cell B, a figure is not defined, but contents will become an empty character if Cell B is character-ized simply.

[0064] Then, a low-ranking layered structure is developed from the specified cell, and it gives the cell which specified the figure defined by the low rank cell. The figure defined by this example in the cell F1 currently referred to below in the cell B − F4 is given to Cell B. Thereby, the character-ized effect of Cell B increases.

(2) As shown in partial extraction drawing 14 of a pattern, if it is an analogous pattern at Cell F, as for Cell E and Cell P, a similar portion can be started and it can replace in the same character, the efficiency of character drawing will increase. Then, the function which cuts down some patterns in a cell and is used as a new candidate cell

is needed.

(3) Although pattern recognition cell identification numbers differ, the same pattern may be defined as the interior. If these are extracted as a separate character or VSB drawing of one side is carried out, the efficiency of CP drawing will fall. Then, pattern recognition is performed, a pattern is inspected and a cell identification number is unified about the cell of the same content. If it combines with pattern partial extraction of the preceding clause (2), it will become possible to character-ize a part of cell containing a similar target.

(4) The example by which array arrangement of the candidate cell smaller than the array reconstruction maximum beam size is carried out is shown in drawing 15 . When the maximum beam size is 2 micrometers, it is [ 3 micrometers and the array arrangement pitch of the least common multiple of the maximum beam size and an array arrangement pitch ] 6 micrometers. If a candidate cell is developed in this field, a 3x3=9 piece cell will enter like drawing 15 (a). If this is divided with the maximum beam size, it will be divided into four cells like drawing 15 (b), and array arrangement structure will be reconfigurated. If the cell created by this array reconstruction is character-ized, respectively, although the number of character kinds will increase, the total shots per hour decreases. In the example shown here, the number of characters increases from one piece to four pieces, and the total shots per hour is decreasing to four ninths.

[0065] After performing the above candidate cell reconstruction, the candidate cell of a predetermined number is chosen as a second candidate cell by the 53d of the second candidate cell selection sections, and character-ized effect evaluation section 53e estimates a character-ized effect. If a difference with the drawing time the case where VSB drawing of the selected second candidate cell is carried out as an evaluation norm of a character-ized effect here, and at the time of character-izing is computed and used, evaluation more near reality can be performed and it will become possible to evaluate a suitable character-ized effect.

[0066] Furthermore, while changing various combination of the second-chosen candidate cell and evaluating a character-ized effect, depending on the case, it can ask for a more suitable character set again by repeating candidate cell reconstruction, the second candidate cell selection, and character-ized effect evaluation.

[0067] Thus, according to this example, before constituting the drawing data origination means 50 like drawing 10 and separating a VSB drawing pattern and CP drawing pattern, the drawing data with which adjustment with the pattern which can extract easily the figure group which carries out package drawing by the character

beam from design pattern data, and carries out VSB drawing was also maintained can be created by performing hierarchical graphic data processing. And since a set of the extracted character figure will become suitable, the time which drawing data origination takes can be shortened and a drawing throughput can be raised. Consequently, the productivity of LSI can be raised while raising the operating ratio of an electron beam exposure system.

[0068] In addition, this invention is not limited to each example mentioned above. Although the combination of a candidate cell was searched for in the 1st example, having used as four pieces the number of the character cells formed in a aperture mask, the number of character cells is not limited to this, and can be changed suitably. Furthermore, it is not necessary to necessarily make the number of character cells regularity, and it may make the number of character cells adjustable with the size of a candidate cell. For example, what is necessary is just to search for the combination of a candidate cell, as the sum of the area of each candidate cell goes into predetermined within the limits, when the sizes of a candidate cell differ.

[0069] Moreover, the composition of the equipment for carrying out this invention is not limited to drawing 1 at all, and it should just draw the frame divided into predetermined width of face one by one, carrying out continuation movement of the stage in which the sample was laid using the aperture mask with which the aperture for elementary figures and the aperture for characters were formed. furthermore, although the example explained the electron beam machine, it comes out not to mention being applicable similarly in an ion beam aligner

[0070] Moreover, it is also possible to aim at much more improvement in a drawing throughput by using combining aperture pattern determination processing in which it explained in drawing data origination processing in which it explained in the 2nd example, and the 1st example. In addition, in the range which does not deviate from the summary of this invention, it can deform variously and can carry out.

[0071]

[Effect of the Invention] Drawing time deltaAc shortened when the drawing time A at the time of using only the variable shaped beam of each sample area and each CP candidate cell c are character-ized according to this invention (claim 1), as explained in full detail above is once calculated about all sample area. By computing the drawing time drawn from A and delta Ac the stage speed of each combination of CP candidate cell, and from now on The effect of CP drawing method can fully be demonstrated, very high drawing of a throughput can be performed, and it becomes possible to realize the electric charge beam drawing method that CP cell which should moreover

be formed in a aperture mask can be extracted easily.

[0072] Moreover, according to this invention (claims 2-4), the processing which separates the pattern by which VSB drawing is carried out, and the pattern by which CP drawing is carried out is preceded. The configuration of a character beam is determined by making the figure group (cell) used as the batch of hierarchical graphic data processing into a unit. By replacing the character-ized figure group by the continuous-path-control code, and outputting a VSB drawing pattern and a continuous-path-control code as drawing data per drawing field The figure group which carries out package drawing by the character beam can be easily extracted from design pattern data. And adjustment with the pattern which carries out VSB drawing can also be maintained, drawing data can be created, and it becomes possible to realize the electric charge beam drawing equipment which shortens the time which drawing data origination takes and can aim at improvement in a drawing throughput.

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The outline block diagram showing the electron beam exposure system used for the 1st example.

[Drawing 2] The ** type view showing the structure of beam fabrication aperture.

[Drawing 3] The ** type view showing the configuration of a shaped beam.

[Drawing 4] The ** type view showing the system of drawing data.

[Drawing 5] The flow chart which shows the processing outline in the example method.

[Drawing 6] The ** type view showing the example of the repeat pattern which draws in the example.

[Drawing 7] The ** type view showing the example of CP candidate cell used in the example.

[Drawing 8] The flow chart for explaining processing of the drawing time calculation in an example.

[Drawing 9] The ** type view showing the method of the stage speed calculation in an example.

[Drawing 10] The block diagram in which being for explaining the 2nd example and showing the composition of a drawing data origination means.

[Drawing 11] Drawing showing the example of a pattern of a character beam drawing field and a basic form-like beam drawing field.

[Drawing 12] The block diagram showing the composition of the character-ized cell determination processing section.

[Drawing 13] It is a view in order to explain partial expansion processing of a layered structure.

[Drawing 14] Drawing for explaining pattern partial extraction processing.

[Drawing 15] Drawing for explaining array reconstruction processing.

[Drawing 16] The ** type view for explaining the drawing method of the conventional stage continuation move mode.

[Description of Notations]

10 -- Sample room 11 -- Sample

12 -- Table 13 -- Table drive circuit

14 -- Position circuit 20 -- Electron optics system

21 -- Electron gun 22-26 -- Lens

31-34 -- Deflecting system 35 36 -- Beam fabrication aperture

40 -- Control computer 41 -- Magnetic disk (storage)

42 -- Pattern memory 43 -- Pattern data decoder

44 -- Drawing data decoder 45 -- Blanking circuit

46 -- Beam fabrication machine driver 47 -- Main deflection-circuit driver

48 -- Subdeflecting system driver 50 -- Drawing data origination means

51 -- Layered structure recombination processing section 52 -- Hierarchical graphic-data-processing section

53 -- Character-ized cell determination processing section 54 -- Character control-code substitution processing section

55 -- The drawing data output section classified by drawing field 60 -- Drawing means

[Translation done.]

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審査請求 未請求 請求項の数5 ＯＬ （全 16 頁）

(71)出願人 000003078
株式会社東芝
神奈川県川崎市幸区堀川町72番地
(72)発明者 原 重博
神奈川県川崎市幸区小向東芝町1番地 株
式会社東芝研究開発センター内
(72)発明者 馬越 俊幸
神奈川県横浜市磯子区新磯子町33番地 株
式会社東芝生産技術研究所内
(72)発明者 小山 清美
神奈川県川崎市幸区小向東芝町1番地 株
式会社東芝研究開発センター内
(74)代理人 弁理士 鈴江 武彦

最終頁に続く

(54)【発明の名称】 荷電ビーム描画方法及び描画装置

(57)【要約】
【目的】 ＣＰ描画方式の効果を十分に発揮してスルーブットの極めて高い描画を行うことができ、しかもアバーチャマスクに形成すべきＣＰセルの抽出を容易に行い得る電子ビーム描画方法を提供すること。
【構成】 ステージを連続移動しながらフレームを順次描画するＣＰ方式の電子ビーム描画方法において、サンブルエリアを基本図形用アバーチャのみで描画するに必要な描画時間Ａと各候補セルをキャラクタ化して描画した場合の短縮時間ΔＡｃを全てのサンブルエリアで求めた後、アバーチャ36に形成する候補セルの全ての組合せに対し、対応する短縮時間ΔＡｃの和を描画時間Ａから引くことで各サンブルエリアにおける描画時間を算出し、描画時間が最も長いサンブルエリアを元に各フレームの描画時間を求め、これらフレーム描画時間の和で与えられる描画全領域の描画時間が最も短い候補セルの組合せをアバーチャ36上に形成する。

1
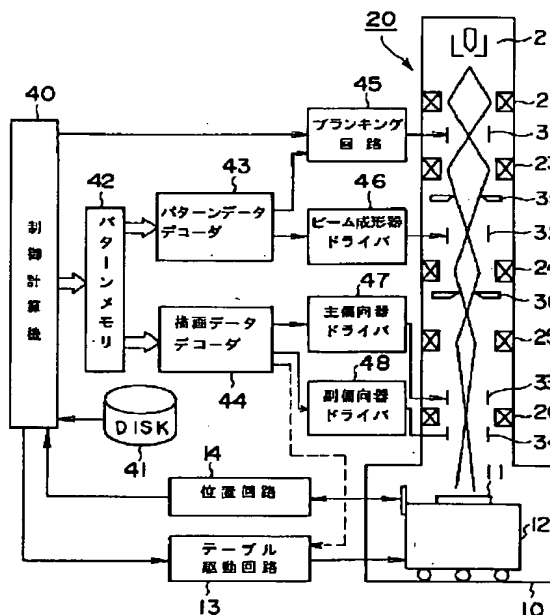
【特許請求の範囲】

【請求項1】基本図形に対応する成形ビームを形成するための基本図形用アパーチャと繰り返しパターンに相当するキャラクタ用アパーチャとが形成されたアパーチャマスクを用い、試料を載置したステージを連続移動しながら、所定幅に分割された描画領域（フレーム）を順次描画する荷電ビーム描画方法において、

描画すべき所望のデータの中から繰り返し使用されるパターンをそれぞれ抽出してキャラクタセルにすべき候補セルとし、

前記フレームをステージ連続移動方向に仮想的に小領域（サンプルエリア）に分割し、該サンプルエリアを基本図形用アパーチャのみを用いて描画するに必要な描画時間Aと各々の候補セルに対し該セルをキャラクタ化して描画した場合の各短縮時間△Acとを全てのサンプルエリアについて求めた後、

各々の候補セルから前記アパーチャマスクに形成するキャラクタ用アパーチャの所定数を選んで全ての組み合わせを作成し、全ての組み合わせに対して、対応する短縮時間△Acの和を描画時間Aから引くことにより、各々のサンプルエリアにおける描画時間を算出し、

前記各フレームにおける描画時間が最も長いサンプルエリアの描画時間Tを求めて、（フレームの長さ／サンプルエリアの幅）×Tによって各々のフレームの描画時間を求め、これらのフレーム描画時間の和で与えられる描画全領域の描画時間を算出し、

描画全領域の描画時間が最も短い候補セルの組み合わせを求め、この組み合わせで前記アパーチャマスク上のアパーチャパターンを形成することを特徴とする荷電ビーム描画方法。

【請求項2】描画すべきパターンに繰り返し現れる繰り返し単位と同じ形状に形成されたキャラクタビームと、矩形及び直角二等辺三角形などの基本形状に成形された基本形状ビームとを組み合わせて所望パターンを描画する荷電ビーム描画装置において、

LSIの設計パターンデータから描画パターンデータを作成するための描画データ作成手段は、

設計パターンデータが有する階層的参照構造を維持した状態で所定の図形データ処理を行う階層的図形データ処理部と、前記階層的図形データ処理を可能とするために予め設計パターンデータの階層構造を再構成する階層構造組み替え処理部と、前記階層的図形データ処理後のパターンデータをキャラクタビームにより描画するパターン群と基本形状ビームの組み合わせにより描画するパターン群とに分離するキャラクタ決定処理部と、前記キャラクタビームにより描画するパターン群をビーム形状の種別を示す制御コードに置換するキャラクタ制御コード置換処理部と、前記基本形状ビームにより描画するパターンの図形データと前記キャラクタビームの種別を示す制御コードとを描画可能な単位領域に対して割り振る描

2

画領域別描画データ出力部と、からなることを特徴とする荷電ビーム描画装置。

【請求項3】前記キャラクタ決定処理部は、前記階層的図形データ処理の際に処理単位となったパターン群（セル）を単位として前記図形データ処理の結果を解析して、セル識別番号，セル参照数，セルサイズ，基本形状ビーム換算ショット数及びキャラクタビーム換算ショット数を算出するセル情報解析処理と、キャラクタ化効果の高いセルをキャラクタ化候補セルとして選択する第1次キャラクタ化候補セル選択処理と、候補セルとして選択されたセルのパターン定義内容を加工するキャラクタ化候補セル再構成処理と、再構成された候補セルから所定数を選択する第2次キャラクタ化候補セル選択処理と、選択されたセルの組み合わせについてキャラクタ化効果を評価するキャラクタ化効果評価処理とから構成され、

キャラクタ化候補セル再構成処理，第2次キャラクタ化候補セル選択処理及びキャラクタ化効果評価処理を繰り返して適切なキャラクタ化セルの組み合わせを決定することを特徴とする請求項2記載の荷電ビーム描画装置。

【請求項4】前記キャラクタ化候補セル再構成処理が、パターン存在領域の外接矩形が所定サイズ以下のセル内に定義されているパターン、又は指定したセル内に定義されているパターンを当該セルを参照しているセルに展開する部分的階層展開処理工程と、セル内の図形群を部分的に抽出して新たにセルとして定義する部分抽出処理工程と、セル識別番号は異なるが内部に定義されているパターン形状が同一ならば同じセルとみなすパターン認識処理工程と、アレイ参照されているセルの参照ピッチと最大ビーム寸法の最小公倍数を求めてその範囲内に当該セルアレイを展開した後、最大ビーム寸法で分割するアレイ再構成処理工程、から構成されていることを特徴とする請求項3記載の荷電ビーム描画装置。

【請求項5】前記キャラクタ決定処理部におけるキャラクタ化効果を評価する際の評価規範として、基本形状ビームにより描画した際の描画時間とキャラクタビームにより描画した際の描画時間との差を算出し、キャラクタ化効果の高いセルを所定数だけキャラクタ化することを特徴とする請求項2記載の荷電ビーム描画装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、LSIなどの半導体集積回路のパターンをマスクやウエハなどの試料に高速・高精度に描画するための荷電ビーム描画技術に係わり、特にメモリデバイスに代表される繰り返しパターン部を一括露光する荷電ビーム描画方法及び描画装置に関する。

【0002】

【従来の技術】電子ビーム露光装置は、ビーム径に相当する極めて微細なパターンを描画できると共に、偏向及

3

びビームの歪みと収差を電気的に補正できるため精度が高いという長所があり、現在、ＬＳＩ開発ツール及びマスク製造ツールとして広く利用されている。

【０００３】この電子ビーム露光装置としては、従来、ガウシアン・ビームや可変成形ビームによっていわゆる一筆書きの要領で描画する装置が主流であったが、パターンが微細で複雑になればなるほどショット数が増え、スループットが低下するという欠点があった。そこで最近、半導体集積回路は基本回路の多くが同一パターンの繰り返しであることに着目し、それぞれの繰り返しパターン形状に対応する多数の透過孔を形成したマスク（以下、アパーチャマスクと呼ぶ）を備えた一括露光（キャラクタプロジェクション、以下ＣＰと略す）方式の電子ビーム露光装置が開発されている。

【０００４】ところで、ＣＰ方式の電子ビーム露光装置では、繰り返し現れる図形や図形群を全てアパーチャマスクに組み込むことは不可能なため、残りは基本図形の組み合わせで描画する必要がある。そのため、アパーチャマスクにどの図形或いは図形群を組込むかによって描画時間が変わってくる。即ち、アパーチャマスクに組み込むためのパターンとして適切なものを選択することが、描画のスループットを上げる上で極めて重要である。

【０００５】第１の従来例として、特開平５－１３３１３号公報においては、パターンデータの中から繰り返し使用されるパターンデータを抽出し、該パターンデータを所定サイズ毎に分割して候補ブロックデータとすると共に、該候補ブロックデータに対して露光ショットの総数が少なくなる順に高い有効度を設定し、該候補ブロックデータの中から選択的に所定数のブロックパターンを抽出するブロックパターン抽出手段を備えるように構成している。

【０００６】第２の従来例として、特開平４－３２００２１号公報においては、アパーチャマスクに組み込むパターンとしては、描画すべきパターンに繰り返し現れる特徴図形若しくは特徴図形群の中から、前記基本図形用アパーチャに対応する成形ビームの組み合わせでショットしたと仮定した場合により多くのショット数を要する特徴図形若しくは特徴図形群を、優先的に選んで形成し、露光ショットの総数を少なくすることが記載されている。

【０００７】ところで、電子ビーム露光装置には、描画されるべきウエハが置かれた試料台（ステージ）を連続的に移動しながら描画を行う、ステージ連続移動描画方式と呼ばれるものがある。図１６に示すように、この方式は全描画領域を電子ビームの偏向可能な幅（フレーム）で分割し、ステージを連続的に移動しながらフレーム単位に描画して行く方式である。なお、ステージ速度は各フレームで一定であるものとする。

【０００８】このようなステージ連続移動の電子ビーム

4

描画方式では、各フレームの描画時間は（フレーム長／ステージ速度）で与えられ、描画領域全体の描画時間は該フレームの描画時間の和とステージ端での折り返しの時間などのオーバーヘッドの時間の和で与えられる。従って、この方式では、描画時間はステージ速度によって決まり、描画スループットを向上させるためには、可能な限りステージ速度を最適化して高速化する必要がある。

【０００９】第３の従来例として、特開平４－６１２２１号公報では、ステージを実際に移動させることなく、ステージの最適移動速度を簡易に求めることができる荷電ビーム描画方法が提案されている。この方法では、サンプルエリア毎に描画に要する必要描画時間を求め、ある一定の速度でステージを移動したと仮定してこの速度における小領域の最大描画時間を求め、フレーム内の小領域を端から順に評価して各小領域の必要時間を加えた値Ａと、評価した小領域の数に相当する最大描画時間の和Ｂとを比較する。そして、これらの差Ａ－Ｂが最大ビーム偏向幅に含まれる最大描画時間の和Ｃを越えるか否かを判断基準にして、Ａ－ＢがＣを越えない略最大のステージ移動速度を決定している。

【００１０】このように、ＣＰ方式を採用した電子ビーム描画方法においては、抽出した候補ブロックデータに対して露光ショットの総数が少なくなる順に高い有効度を設定し、候補ブロックから選択的に所定数のブロックパターンを抽出してＣＰ露光するブロックとして決定する方式がとられている。

【００１１】しかしながら、ステージ連続移動描画方式の場合には、描画時間は最終的にはステージ速度という形で決定される。各フレームのステージ速度は、フレームにおけるショット数の総数だけでなく、ショット数の粗密の分布やセルデータの配置様式などによって決まる。このため、ステージ連続移動の荷電ビーム描画方式では、露光ショットの総数が少なくなる順にＣＰセルとして採用しても、ショット数の粗密の分布やセルデータの配置様式などによっては、ステージ速度が変化せず、従って描画のスループットが向上しないという問題点があった。

【００１２】また、第３の従来例から容易に類推されるように、ＣＰ候補セルから所定数の候補セルを選び出してできる全組み合わせを作成し、組み合わせのそれぞれについてステージ速度及び描画時間を算出し、描画時間が最も短くなる組み合わせを選択する方法が予想される。しかしながら、この方法では、全組み合わせの１つ１つについて、繰り返し第３の従来例の方法を適用してそれぞれの描画時間を求めるため、その処理の時間が膨大になるという問題が予想される。

【００１３】一方、ＣＰ方式を採用した電子ビーム描画装置を用いて回路パターンを描画する場合、ＣＡＤ（Computer Aided Design）等の回路パターン設計ツールを

用いて作成された設計パターンデータを、電子ビーム描画装置に入力可能なデータ形式、即ち描画方式及び描画装置の仕様等の条件を満たした電子ビーム描画データ形式に変換する必要がある。このような「設計データから描画データへの変換処理」を、一般に「電子ビーム描画データ変換」と呼んでいる。従来のVSB方式描画装置に必要な電子ビーム描画データ変換の処理内容をまとめると、以下のようになる。

（1）レイヤー間図形論理演算（AND，OR，NOT等）

（2）パターン重複除去（多重露光の防止を目的）

（3）リサイズ（太め／細め）

（4）倍率補正（拡大／縮小）

（5）回転補正（回転／鏡像）

（6）描画領域単位の分割（サブフィールド領域／フレーム領域などの境界線で分割）

（7）基本図形分割（描画装置に入力可能な基本図形に分割／近似）

（8）データ形式変換（描画装置固有の表現形式に変換して出力）

回路パターンを設計する場合、設計者はまずセルと呼ばれる図形群を定義し、これを別のセル内で呼び出して配置し、多くのセルを組み合わせることによって全体のパターンが構成される。このような設計データが有する階層的なセル参照構造を維持したまま上記図形処理を行うことにより、描画データ変換の処理時間の短縮と、描画データ量の圧縮が図られている。このような処理手法を階層的図形データ処理と呼んでいる。

【0014】CP方式を採用した描画装置は、規則的パターンはCP方式で、不規則パターンはVSB方式で描画する。そのため、CP方式に対応した描画データ変換処理では、上記機能に加えて、基本形状ビームによってVSB描画するパターンと、キャラクタビームによってCP描画するパターンとを分離するデータ処理が必要となる。

【0015】この分離処理は、回路パターンを構成する多数の図形から規則性を求めて、その繰り返しの単位図形群をキャラクタ形状として抜き出す必要がある。その際には、VSB描画パターンとCP描画パターンの間に重複や間隙などの描画データ上のエラーを発生させないこと、描画スループットを最適とするキャラクタ図形の集合を効率良く抽出することの2点が重要である。特に後者においては、装置仕様に基づくキャラクタ種類数と最大ビーム寸法の制限下で描画スループットが最良となるキャラクタ図形の集合を求める必要があり、その処理が極めて複雑である。このため、データ処理時間が長くなり、描画システム全体のスループットをも低下させてしまうという問題があった。

【0016】

【発明が解決しようとする課題】このように従来、CP

方式を採用したステージ連続移動の荷電ビーム描画方式では、描画時間が最終的にはステージ速度という形で決定されるため、露光ショットの総数が少なくなる順にCPセルとして採用しても、ショット数の粗密の分布やセルデータの配置様式などによってはステージ速度が変化せず、従って描画のスループットが向上しないという問題があった。さらに、第3の従来例から類推される方法では、全ての組み合わせの1つ1つについて、繰り返し第3の従来例の方法を適用してそれぞれの描画時間を求めるため、その処理の時間が膨大になるという問題が予想される。

【0017】また、CP方式を採用した荷電ビーム描画装置においては、設計データから描画データを作成するために、基本形状ビームによってVSB描画するパターンとキャラクタビームによってCP描画するパターンとを分離する図形データ処理が必要となり、この分離処理のためのデータ処理時間が長くなり、描画システム全体のスループットをも低下させてしまうという問題があった。

【0018】本発明は、上記事情を考慮してなされたもので、その目的とするところは、CP描画方式の効果を十分に発揮してスループットの極めて高い描画を行うことができ、しかもアパーチャマスクに形成すべきCPセルの決定を容易に行い得る荷電ビーム描画方法を提供することにある。

【0019】また、本発明の他の目的は、設計パターンデータからキャラクタビームにより一括描画する図形群を容易に抽出することができ、かつVSB描画するパターンとの整合性も保って描画データを作成することができ、描画データ作成に要する時間を短縮して描画スループットの向上をはかり得る荷電ビーム描画装置を提供することにある。

【0020】

【課題を解決するための手段】本発明の骨子は、各サンプルエリアの可変成形ビームのみを用いた場合の描画時間Aと各CP候補セルcをキャラクタ化した場合に短縮される描画時間$\Delta Ac$とを全サンプルエリアについて一旦求めておき、Aと$\Delta Ac$からCP候補セルの各組み合わせのステージ速度及びこれから導かれる描画時間を算出することにある。

【0021】即ち、本発明（請求項1）は、基本図形に対応する成形ビームを形成するための基本図形用アパーチャと繰り返しパターンに相当するキャラクタ用アパーチャが形成されたアパーチャマスクを用い、試料を載置したステージを連続移動しながら、所定幅に分割された描画領域（フレーム）を順次描画する荷電ビーム描画方法において、描画すべき所望のデータの中から繰り返し使用されるパターンをそれぞれ抽出してキャラクタセルにすべき候補セルとし、フレームをステージ連続移動方向に仮想的に小領域（サンプルエリア）に分割し、該サ

7

ンブルエリアを基本図形用アバーチャのみを用いて描画するに必要な描画時間Aと各々の候補セルに対し該セルをキャラクタ化して描画した場合の各短縮時間△Acとを全てのサンプルエリアについて求めた後、各々の候補セルからアバーチャマスクに形成する所定数を選んで全ての組み合わせを作成し、全ての組み合わせに対して、対応する短縮時間△Acの和を描画時間Aから引くことにより、各々のサンプルエリアにおける描画時間を算出し、各フレームにおける描画時間が最も長いサンプルエリアの描画時間Tを求めて、（フレームの長さ／サンプルエリアの幅）×Tによって各々のフレームの描画時間を求め、これらのフレーム描画時間の和で与えられる描画全領域の描画時間を算出し、描画全領域の描画時間が最も短い候補セルの組み合わせを求め、この組み合わせでアバーチャマスク上のアバーチャパターンを形成することを特徴とする。

【0022】ここで、本発明の望ましい実施態様としては、次のものがあげられる。

(1) ステージの移動速度を、各フレーム毎に最適に設定する。より具体的には、フレームにおいて最も描画時間のかかるサンプルエリアの描画時間をTとし、サンプルエリアの幅／Tによってステージ移動速度を設定する。

(2) アバーチャマスクに形成するキャラクタセルの数を一定として、候補セルの組み合わせを求める。

(3) アバーチャマスクに形成するキャラクタセルの数を候補セルの大きさにより可変にして、候補セルの組み合わせを求める。より具体的には、各々の候補セルの面積の和が所定範囲内に入るようにして候補セルの組み合わせを求める。

【0023】また、本発明の別の骨子は、VSB描画されるパターンとCP描画されるパターンを分離する処理に先立ち、階層的図形データ処理の処理単位となった図形群（セル）を単位としてキャラクタビームの形状を決定し、キャラクタ化する図形群をCP制御コードと置換し、VSB描画パターン及びCP制御コードを描画領域単位に描画データとして出力するように描画データ変換処理を構成することにある。

【0024】即ち、本発明（請求項2）は、描画すべきパターンに繰り返し現れる繰り返し単位と同じ形状に形成されたキャラクタビームと、矩形及び直角二等辺三角形などの基本形状に成形された基本形状ビームとを組み合わせて所望パターンを描画する荷電ビーム描画装置において、LSIの設計パターンデータから描画パターンデータを作成するための描画データ作成手段を、設計パターンデータが有する階層的の参照構造を維持した状態で所定の図形データ処理を行う階層的図形データ処理部と、階層的図形データ処理を可能とするために予め設計パターンデータの階層構造を再構成する階層構造組み替え処理部と、階層的図形データ処理後のパターンデータをキャラクタビームにより描画するパターン群と基本形

8

状ビームの組み合わせにより描画するパターン群とに分離するキャラクタ決定処理部と、キャラクタビームにより描画するパターン群をビーム形状の種別を示す制御コードに置換するキャラクタ制御コード置換処理部と、基本形状ビームにより描画するパターンの図形データとキャラクタビームの種別を示す制御コードとを描画可能な単位領域に対して割り振る描画領域別描画データ出力部と、から構成するようにしたものである。

【0025】ここで、本発明の望ましい実施態様としては、次のものがあげられる。

(1) キャラクタ決定処理部では、セルを単位として階層的図形データ処理の処理結果を解析して、セル識別番号，セル参照数，セルサイズ，基本形状ビーム換算ショット数及びキャラクタビーム換算ショット数からなる一覧表を作成するセル情報解析処理、キャラクタ化効果の高いセルをキャラクタ候補セルとして選択する第1次キャラクタ化候補セル選択処理、候補セルとして選択されたセルのパターン定義内容を加工するキャラクタ化候補セル再構成処理、再構成された候補セルから所定数だけ選択する第2次キャラクタ化候補セル選択処理、選択されたセルの組合せについてキャラクタ化効果を評価するキャラクタ化効果評価処理といった処理を施し、キャラクタ化候補セル再構成処理，第2次キャラクタ化候補セル選択処理及びキャラクタ化効果評価処理を繰り返して適切なキャラクタ化セルの組み合わせを決定すること。

(2) キャラクタ化候補セル再構成処理では、パターン存在領域の外接矩形が所定サイズ以下のセル内に定義されているパターン、又は指定したセル内に定義されているパターンを当該セルを参照しているセルに展開する部分的階層展開処理と、セル名は異なるが内部に定義されているパターン形状が同一のセルを同じセルとみなすパターン認識処理と、アレイ参照されているセルの参照ピッチと最大ビーム寸法の最小公倍数を求めてその範囲内に当該セルアレイを展開した後、最大ビーム寸法で分割するアレイ再構成処理と、セル内のパターンを部分的に抽出して新たにセルとする部分抽出処理とを組み合わせて処理すること。

(3) キャラクタ決定処理部でキャラクタ化効果を評価する際の評価規範として、基本形状ビームにより描画した際の描画時間とキャラクタビームにより描画した際の描画時間との差を算出し、キャラクタ化効果の高いセルを所定数だけキャラクタ化すること。

(4) キャラクタ決定処理部における図形処理として、図形間重複除去，レイヤー間図形論理演算，単位偏向領域境界での図形分割及びリサイズ処理などを行うこと。

【0026】

【作用】本発明（請求項1）の方法によれば、サンプルエリアを基本図形用アバーチャのみを用いて描画するに必要な描画時間Aと候補セルをキャラクタ化して描画した場合の短縮時間△Acとを一度求めれば、CP候補セ

9

ルの全ての組み合わせの描画時間をこれから簡易に求めることができる。その結果、描画時間が最短である候補セルの組み合わせを容易に選択することができる。即ち、ＣＰ描画方式の効果を十分に発揮してスループットの極めて高い描画を行うためのＣＰ候補セルの抽出が、短時間の効率的な処理によって得られる。

【００２７】また、本発明（請求項２～４）によれば、ＶＳＢ描画パターンとＣＰ描画パターンとを分離する前に階層的図形データ処理を行うため、両者の間に重複や間隙といったエラー箇所の無い所望の描画データを短時間で作成できる。このため、分離処理のためのデータ処理時間が短くなり、描画システム全体のスループットを向上させることが可能となる。

【００２８】また、階層的図形処理の処理単位と同じセルを単位に第１次キャラクタ候補としてまず抽出し、分割・融合などの候補セル再構成処理を行った後に再度キャラクタ化効果を評価する２段階選抜方式を採用しているため、適切なキャラクタ図形の組み合わせを短時間で決定することができる。さらに、ＶＳＢ描画とＣＰ描画の時間差でキャラクタ化効果を評価するため、より現実に即した適切なキャラクタ集合を決定することができる。

【００２９】近年のＬＳＩの微細化と高集積化の傾向を鑑みるに、荷電ビーム描画装置の処理性能が深刻な問題となることが予想される。これに対し、本発明のような描画データの作成手段を備えた描画装置は、ＣＰ描画方式に対応する描画データ変換に要する処理時間を短縮できるばかりでなく描画処理性能も同時に高めることができ、その有用性は大である。

【００３０】
【実施例】以下、本発明の実施例を図面を参照して説明する。

（実施例１）図１は、本発明の第１の実施例に使用した電子ビーム露光装置を示す概略構成図である。図中１０は試料室であり、この試料室１０内には半導体ウエハ若しくはガラスマスク等の試料１１を載置したテーブル（ステージ）１２が収容されている。テーブル１２は、テーブル駆動回路１３によりＸ方向（紙面左右方向）及びＹ方向（紙面表裏方向）に駆動される。そして、テーブル１２の位置は、レーザ測長計等を用いた位置回路１４により測定されるものとなっている。

【００３１】試料室１０の上方には、電子ビーム光学系２０が配置されている。この光学系２０は、電子銃２１，各種レンズ２２～２６，ブランキング用偏向器３１，ビーム寸法可変用偏向器３２，ビーム走査用の副偏向器３４及びビーム成形用アバーチャマスク３５，３６などから構成されている。

【００３２】そして、主偏向器３３により所定の単位描画領域（サブフイールド）に位置決めし、副偏向器３４によってサブフイールド内での図形描画位置決めを行う

10

と共に、ビーム形状制御用偏向器３２及びビーム成形用アバーチャマスク３５，３６によりビーム形状及びビーム寸法を制御し、テーブル１２をＸ若しくはＹ方向に連続移動しながらＬＳＩチップをビーム偏向幅に応じて短冊状に分割したフレーム領域を集めた描画ストライプ単位に描画処理する。さらに、テーブル１２を次の描画ストライブの開始位置まで移動し、上記処理を繰り返して各描画ストライブを順次描画処理するものとなっている。

【００３３】一方、制御計算機４０には磁気ディスクを始めとする記憶媒体４１が接続されており、この磁気ディスク４１に描画対象とするＬＳＩチップに係わる描画データが格納されている。磁気ディスク４１から読み出された描画データは、前記描画ストライプ毎の描画データとしてパターンメモリ４２に一時的に格納される。パターンメモリ４２に格納された描画ストライプ毎の描画データ、つまり描画位置及び基本図形データなどで構成される描画ストライプデータは、データ解読部であるパターンデータデコーダ４３及び描画データデコーダ４４により解読され、ブランキング回路４５，ビーム成形ドライバ４６，主偏向ドライバ４７及び副偏向ドライバ４８に送出される。

【００３４】即ち、パターンデコーダ４３では、上記描画ストライプデータを入力し、描画ストライプデータとして定義されている基本図形データを前記ビーム成形用アバーチャマスク３５，３６の組み合わせにより形成可能なＣＰセル図形又は矩形や三角形を始めとする描画単位図形群に図形群に図形分割して、この描画図形情報に基づいて作成されるビーム成形ドライバ４６に送られる。そして、ビーム成形ドライバ４６から電子光学系２０のビーム形状制御用偏向器３２に所定の偏向信号が印加されて、電子ビームのビーム形状及びビーム寸法が制御されるものとなっている。

【００３５】次に、上述した装置におけるビームの生成方法について詳述する。図２（ａ）は、第１のビーム成形用アバーチャマスク３５のビーム通過孔の配置を示すもので、１つのビーム通過孔３５ａが形成されている。図２（ｂ）は、第２のビーム成形用アバーチャマスク３６のビーム通過孔の配置を示しており、第１～第６の通過孔３６ａ～３６ｆが形成されている。

【００３６】図３は、第１のビーム成形用アバーチャマスク３５のアバーチャ像（第１成形アバーチャ像）と第２のビーム成形用アバーチャマスク３６に形成されたビーム通過孔の電子光学的な重ね合わせにより所望のビーム形状及びビーム寸法を生成する様子を示している。図３（ａ）は、第１成形アバーチャ像と第２成形アバーチャマスク３６の第１のビーム通過孔３６ａとの組み合わせにより矩形ビームを生成している状態である。図３（ｂ）は、第１成形アバーチャ像と第２成形アバーチャマスク３６の第２のビーム通過孔３６ｂとの組み合わせ